Red Storm Overview

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System Architecture Goals

- Balanced System Performance: CPU, Memory, Interconnect and I/O
- Usability: Functionality of hardware and software meets needs of users for Massively Parallel Computing
- Scalability: System Hardware and Software scale, single cabinet system to 32K processor system
- Reliability: Machine stays up long enough between interrupts to make real progress on completing application runs (at least 50 hours MTBI), requires full system RAS capability
- Upgradeability: System can be upgraded with a processor swap and additional cabinets to 100T or greater
- Red/Black switching: Capability to switch major portions of the machine between classified and unclassified computing environments
- Space, Power, Cooling: High density, low power system
- Price/Performance: Excellent performance per dollar, use high volume commodity parts where feasible

Red Storm Architecture

- True MPP, designed to be a single system
- Distributed memory MIMD parallel supercomputer
- Fully connected 3D mesh interconnect. Each compute node processor has a bi-directional connection to the primary communication network
- 108 compute node cabinets and 10,368 compute node processors (AMD Sledgehammer @ 2.0 GHz)
- ~30 TB of DDR memory
- Red/Black switching: ~1/4, ~1/2, ~1/4
- 8 Service and I/O cabinets on each end (256 processors for each color)
- > 240 TB of disk storage (> 120 TB per color)

Red Storm Architecture

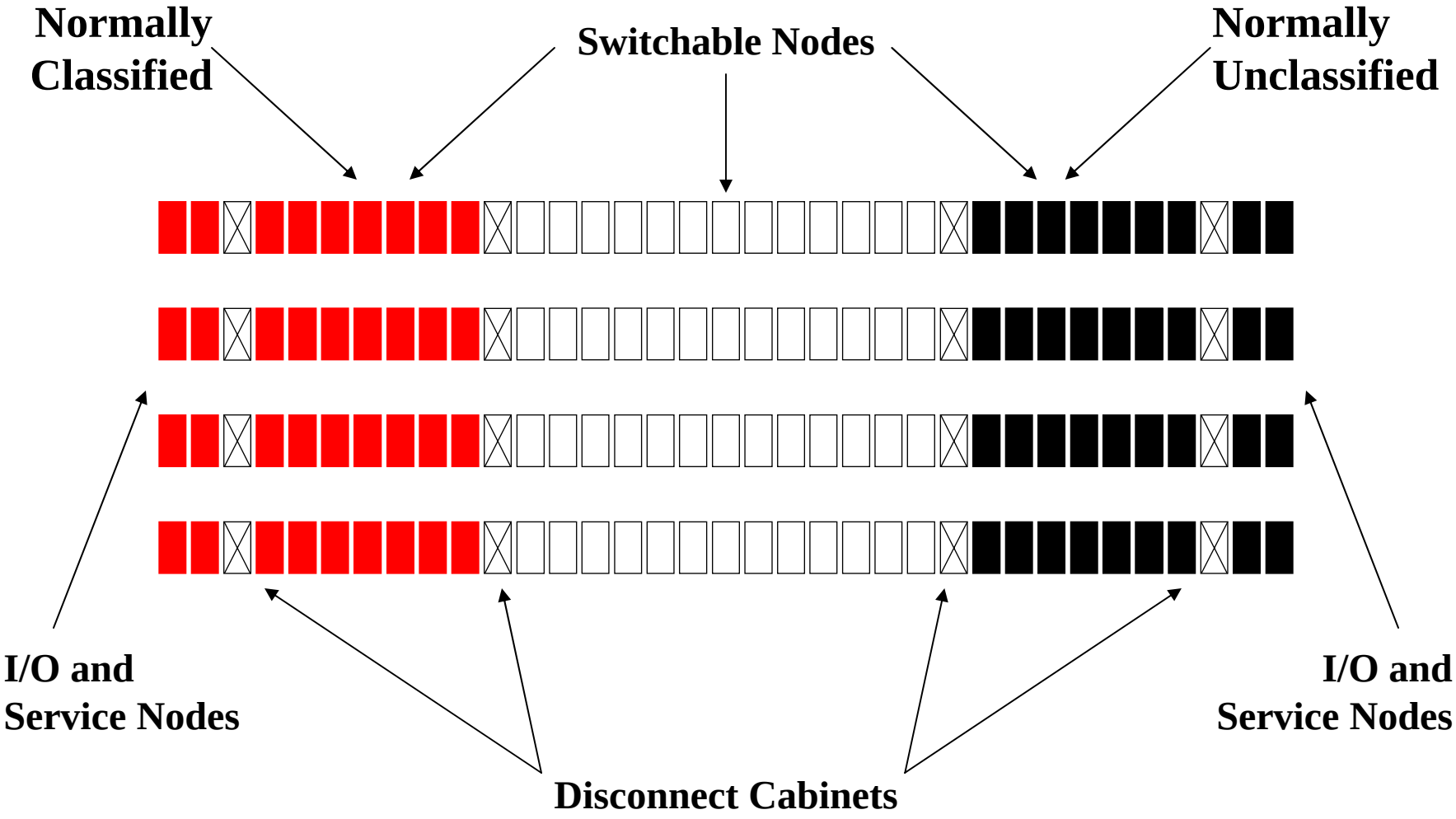
- Functional hardware partitioning: service and I/O nodes, compute nodes, and RAS nodes
- Partitioned Operating System (OS): LINUX on service and I/O nodes, LWK (Catamount) on compute nodes, stripped down LINUX on RAS nodes
- Separate RAS and system management network (Ethernet)
- Router table-based routing in the interconnect
- Less than 2 MW total power and cooling
- Less than 3,000 ft^2 of floor space for machine

Red Storm Topology

- Compute node topology:
  - 27 x 16 x 24 (x, y, z) – Red/Black split: 2,688 – 4,992 – 2,688
- Service and I/O node topology
  - 2 x 8 x 16 (x, y, z) on each end (network is 2 x 16 x 16)
  - 256 full bandwidth links to Compute Node Mesh (384 available)

Red Storm Layout

(27 × 16 × 24 mesh)



Disk storage system not shown

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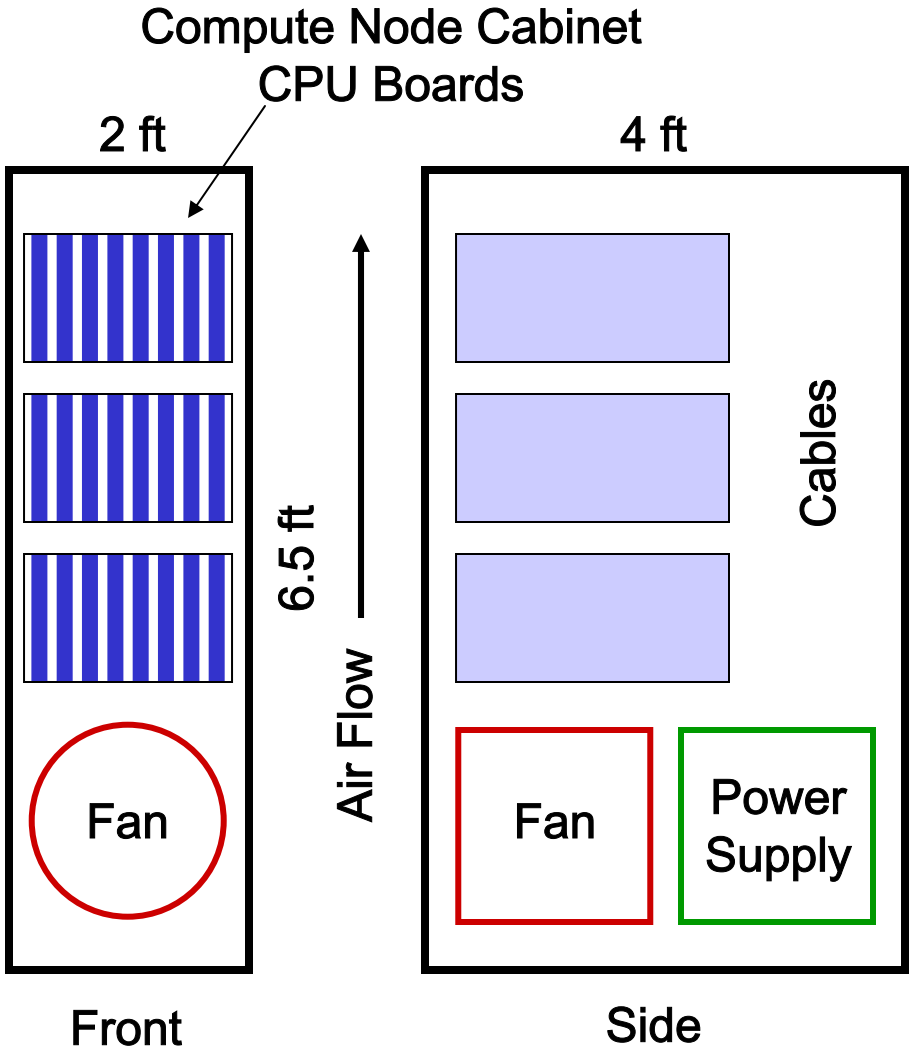
Red Storm Cabinet Layout



- Compute Node Cabinet
  - 3 Card Cages per Cabinet
  - 8 Boards per Card Cage
  - 4 Processors per Board
  - 4 NIC/Router Chips per Board
  - N + 1 Power Supplies
  - Passive Backplane
- Service and I/O Node Cabinet
  - 2 Card Cages per Cabinet
  - 8 Boards per Card Cage
  - 2 Processors per Board
  - 4 NIC/Router Chips per Board
  - PCI-X for each processor
  - N + 1 Power Supplies
  - Passive Backplane

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Red Storm Architecture

- RAS Workstations
  - Separate and redundant RAS workstations for Red and Black ends of machine
  - System administration and monitoring interface
  - Error logging and monitoring for major system components including processors, memory, NIC/Router, power supplies, fans, disk controllers, and disks
- RAS Network: Dedicated Ethernet network for connecting RAS nodes to RAS workstations
- RAS Nodes
  - One for each compute board
  - One for each cabinet

Red Storm System Software

- Operating Systems
  - LINUX on service and I/O nodes
  - LWK (Catamount) on compute nodes
  - LINUX on RAS nodes
- Run-Time System
  - Logarithmic loader
  - Node allocator
  - Batch system – PBS
  - Libraries – MPI, I/O, Math
- File Systems - Lustre for both UFS and Parallel

Red Storm System Software

- Tools
  - ANSI Standard Compilers – Fortran, C, C++
  - Debugger – *TotalView*
  - Performance Monitor - PAPI
- System Management and Administration
  - Accounting
  - RAS GUI Interface

Red Storm Performance

- Peak of ~40 TF based on 2 floating point instruction issues per clock. Expected performance is ~10 times faster than ASCI Red.
- MP-Linpack performance: >14 TF (Expect to get ~30TF)
- Aggregate system memory bandwidth: ~55 TB/s
- Aggregate sustained interconnect bandwidth: >100 TB/s

Red Storm Performance
Processors and Memory

- Processors
  - AMD Sledgehammer (Opteron)
  - 2.0 GHz
  - 64 Bit extension to IA32 instruction set
  - 64 KB L1 instruction and data caches on chip
  - 1 MB L2 shared (Data and Instruction) cache on chip
  - Integrated dual DDR memory controllers @ 333 MHz
  - Integrated 3 Hyper Transport Interfaces @ 3.2 GB/s each direction
- Node memory system
  - Page miss latency to local processor memory is ~80 ns
  - Peak memory bandwidth of ~5.3 GB/s for each processor

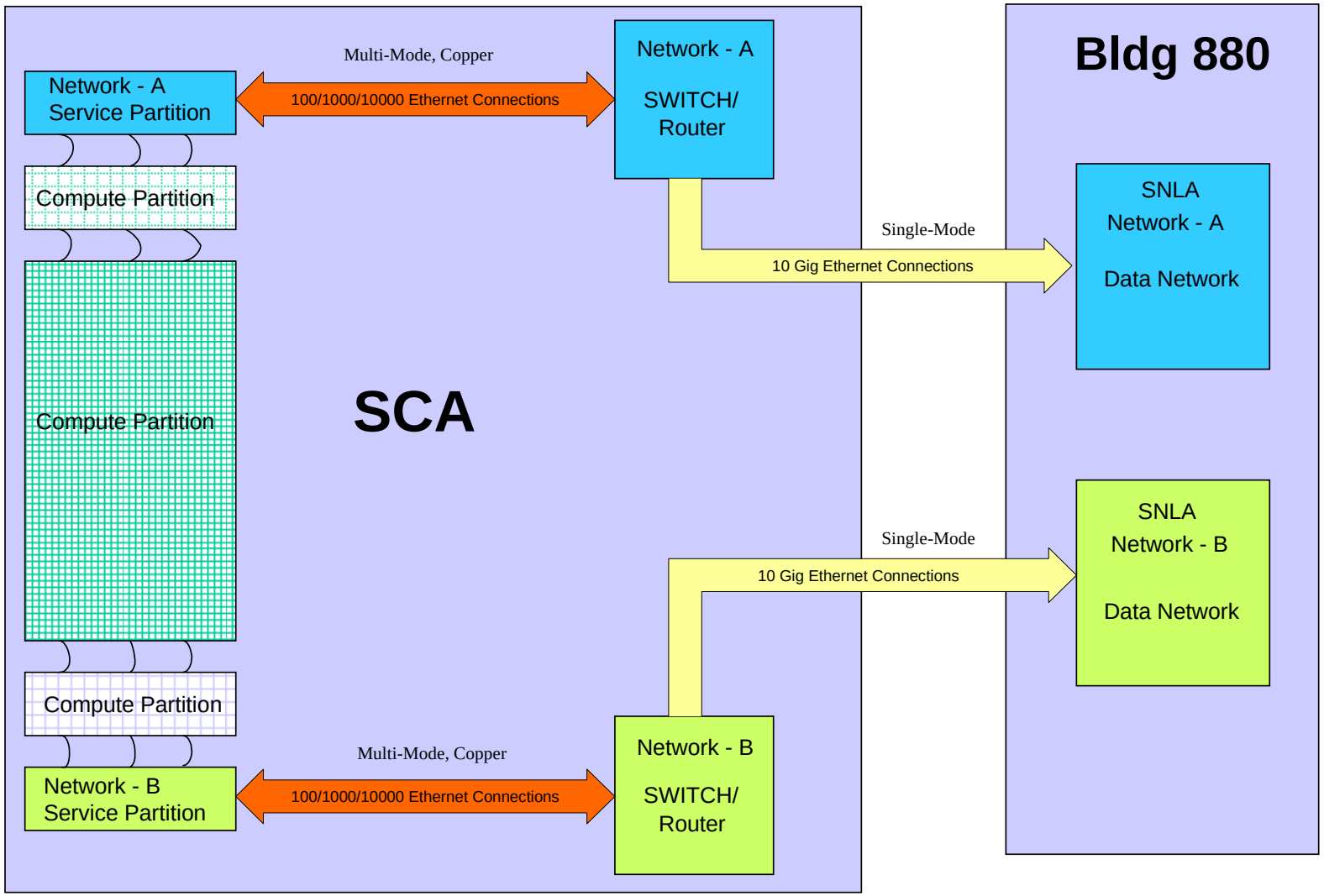
Red Storm Performance
Interconnect and I/O

- Sandia/UNM Portals 3.3 programming interface
- Interconnect performance
  - MPI Latency requirements <2 μs (neighbor), <5 μs (full machine)
  - Peak link bandwidth 3.84 GB/s each direction
  - Bi-section bandwidth ~2.95 TB/s Y-Z, ~4.98 TB/s X-Z, ~6.64 TB/s X-Y
- I/O system performance
  - Sustained file system bandwidth of 50 GB/s for each color
  - Sustained external network bandwidth of 25 GB/s for each color

Red Storm Network Status

The Multiple Networks to Support Red Storm Are Installed and Operational

Red Storm Data Network



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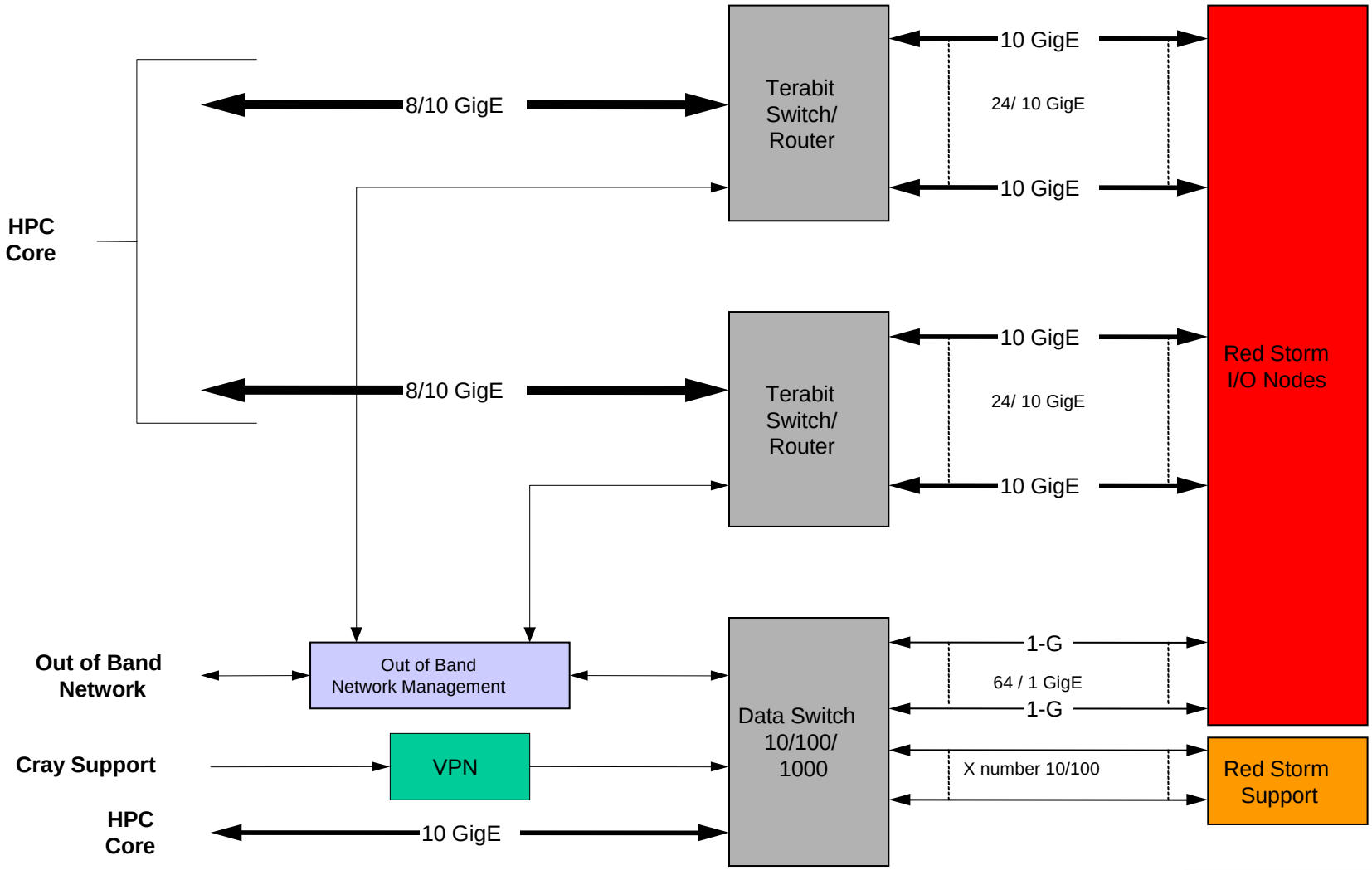
Red Storm Connectivity



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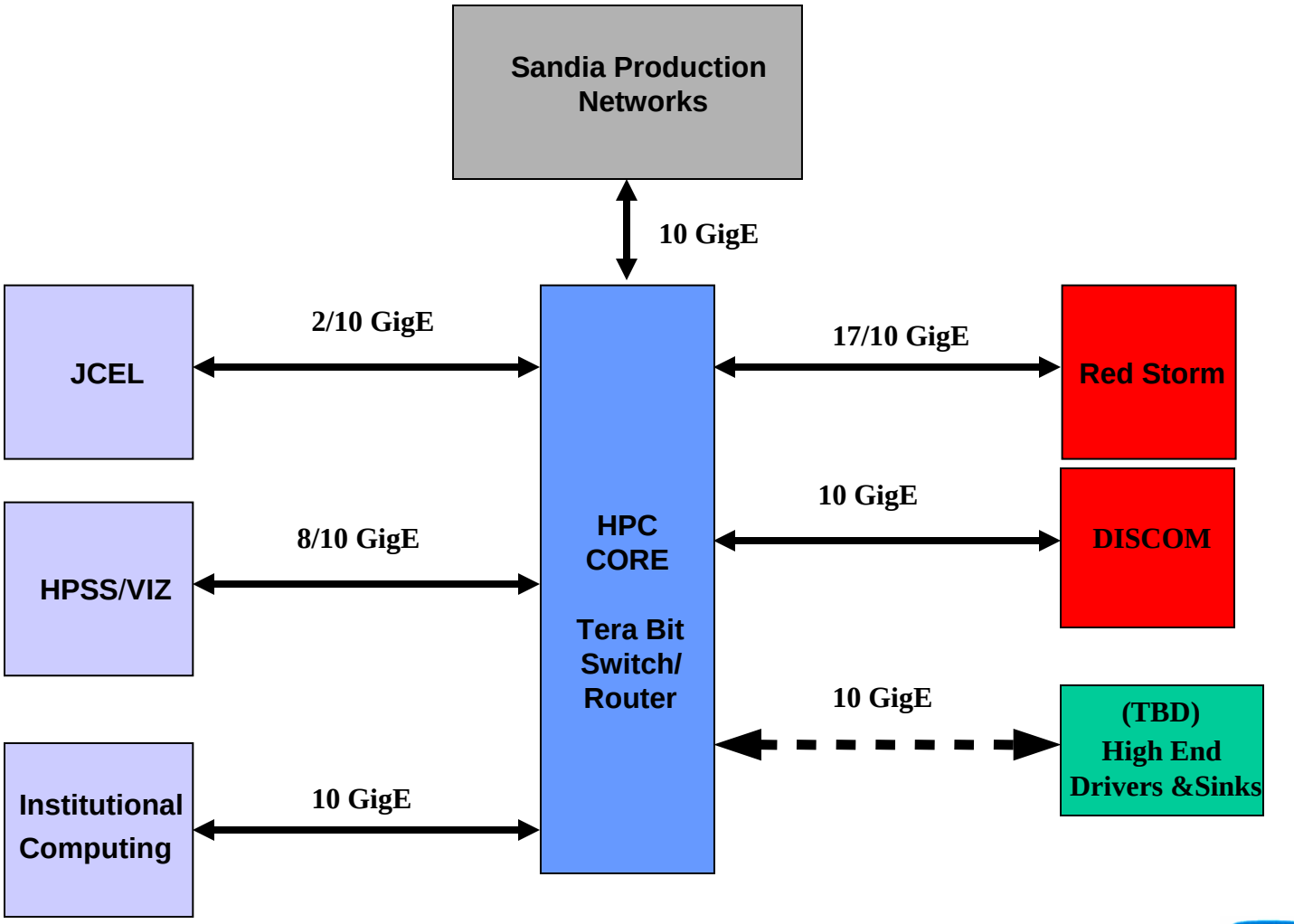
Red Storm Connections To Production Networks



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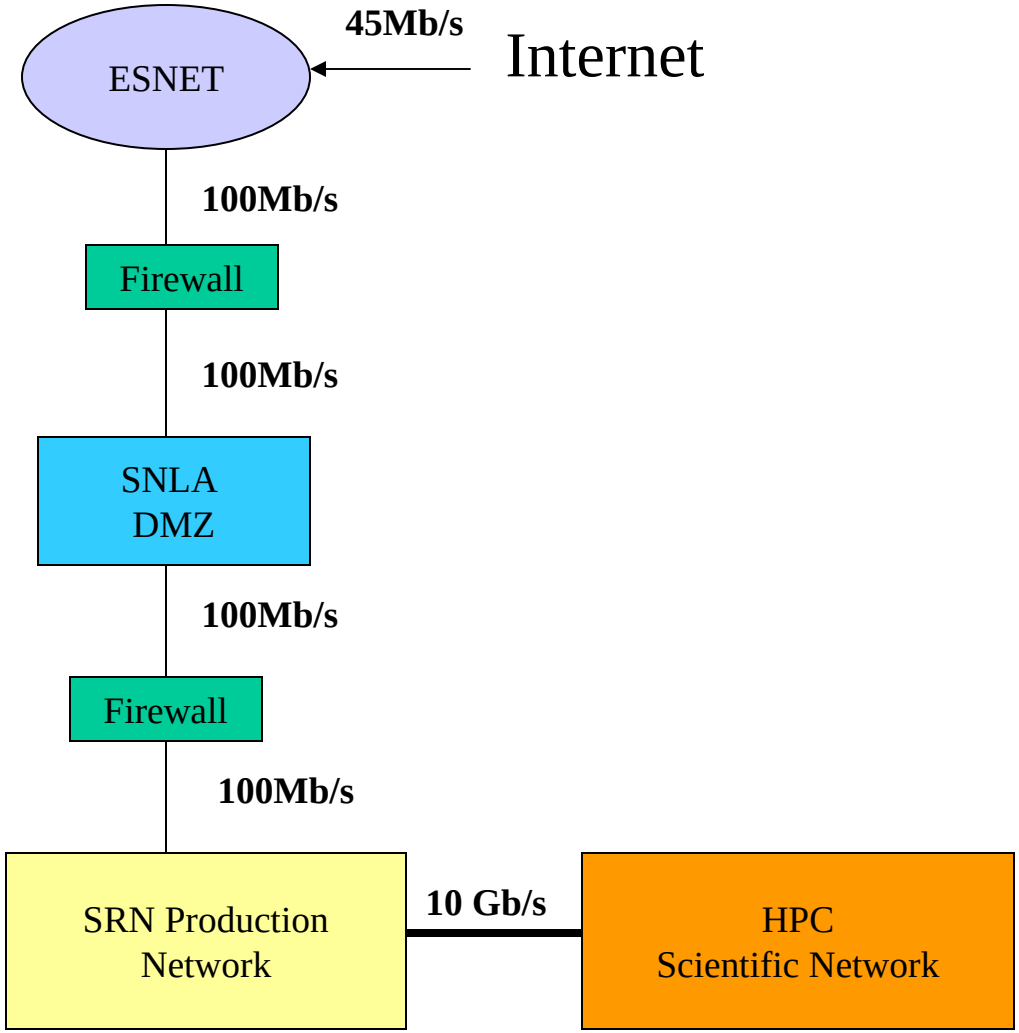
Internet Access to Red Storm



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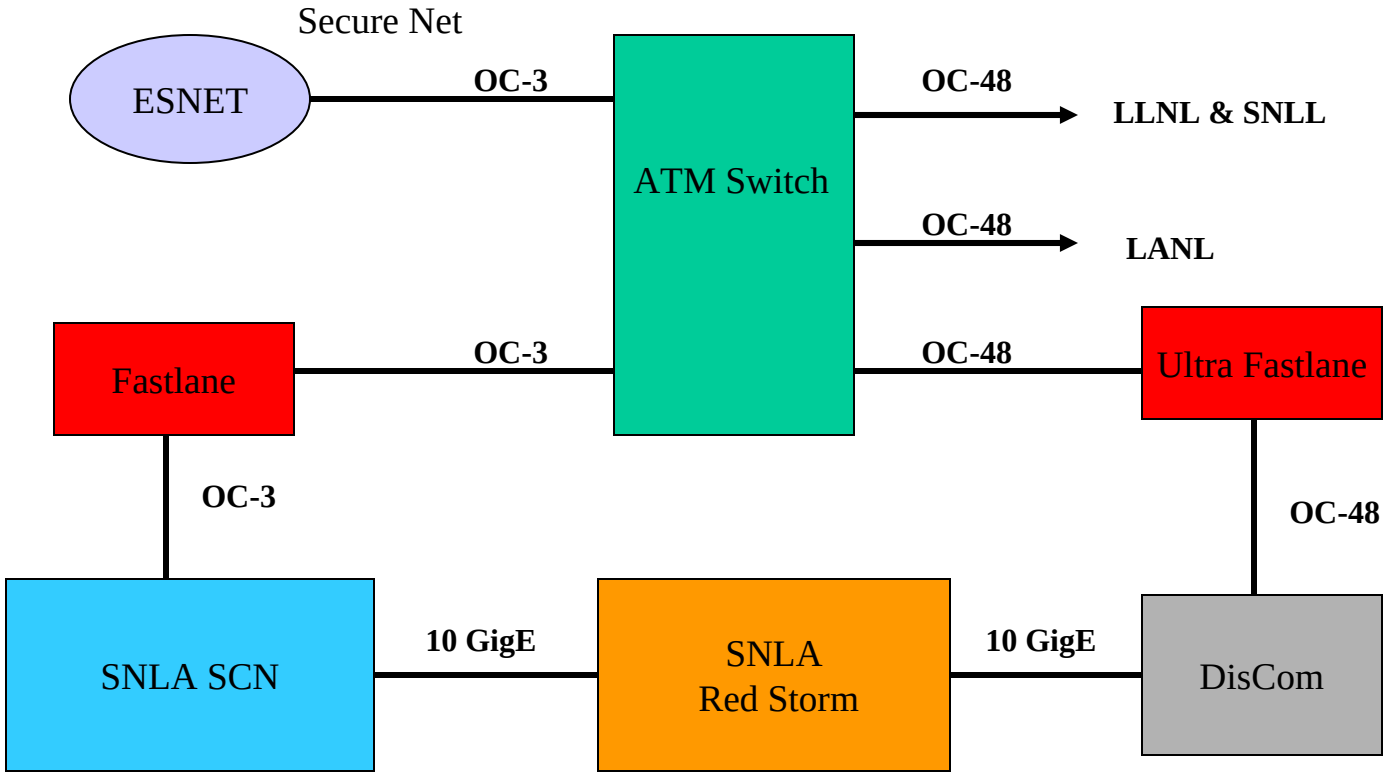
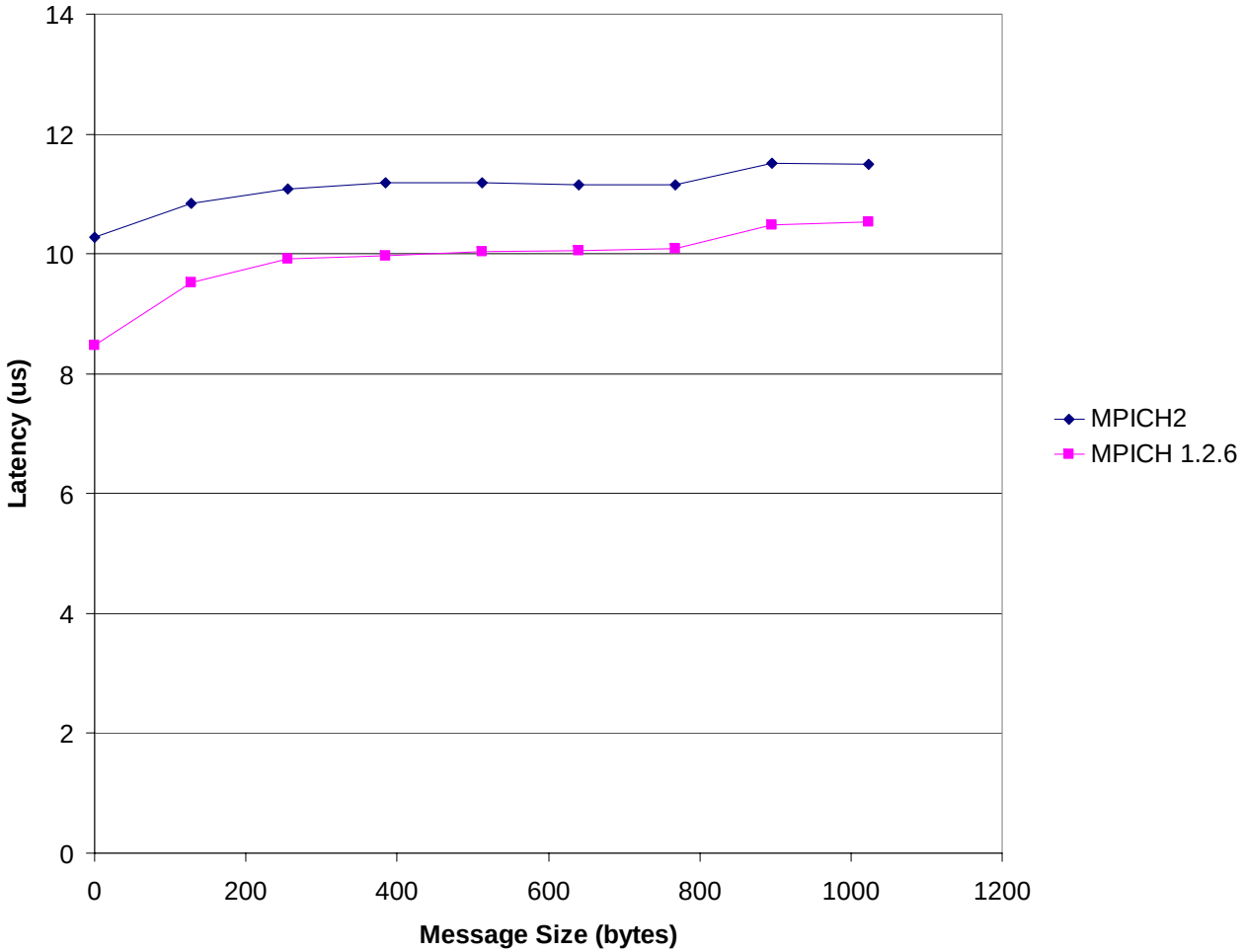
DisCom Access To Red Storm



Red Storm Project Status

- Hardware
  - Full system installed and integrated
- System software is a joint project between Cray and Sandia
  - Sandia Catamount software(Run-time and LWK) is functional and has been tested at scale
  - Currently (3/17) able to boot 2x20
  - Working toward 3x20 and 3x27
  - Limited I/O capability – Lustre not fully operational
- Network
  - Portals firmware is under active development
    - Currently takes interrupts on every new message
    - Latency is ~8.5us
    - Bandwidth is 1.1 – 1.6 GB/s

MPI Ping-Pong



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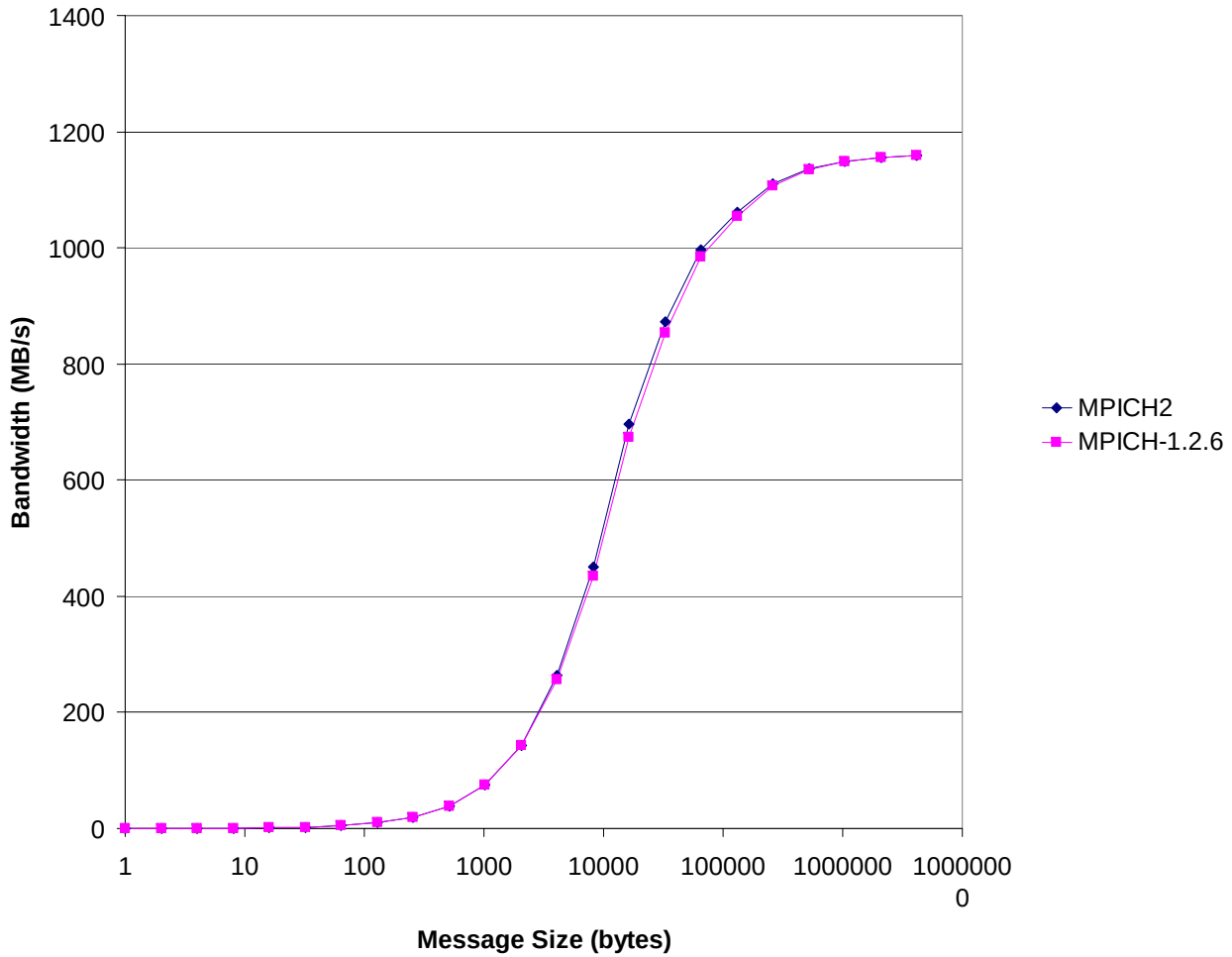
Pallas MPI Ping-Pong



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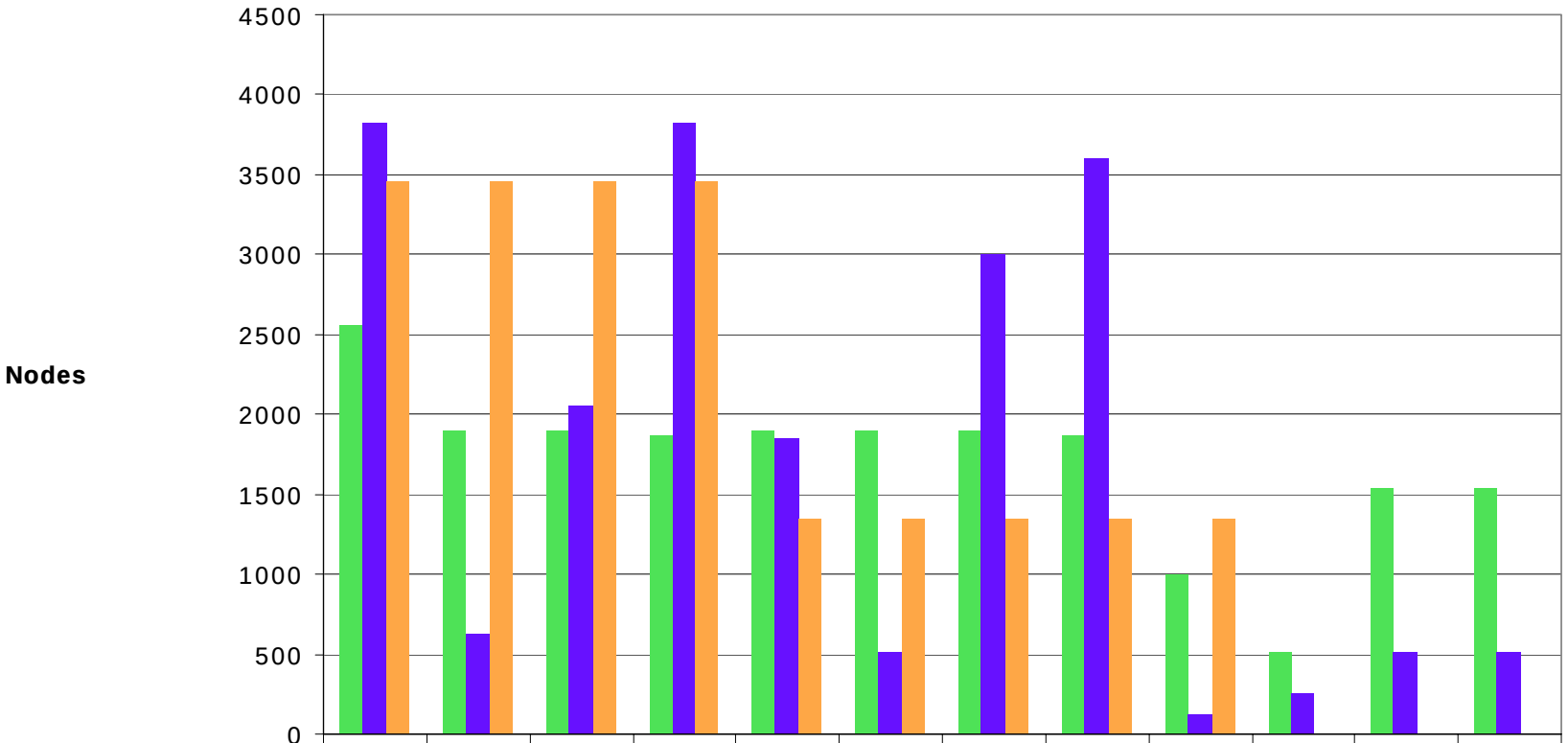
Red Storm Application Status



	BOOT	HPL	CTH	ITS	Sage	Partisn	UMT2K	sPPM	Salinas	Alegra	Presto	Calore
3/18/05 Sandia	2562	1900	1900	1872	1900	1900	1900	1872	1000	512	1536	1536
3/18/05 Cray	3827	625	2048	3827	1850	512	3000	3600	125	256	512	512
3/24/05 Goal	3456	3456	3456	3456	1344	1344	1344	1344	1344		4	4

Applications

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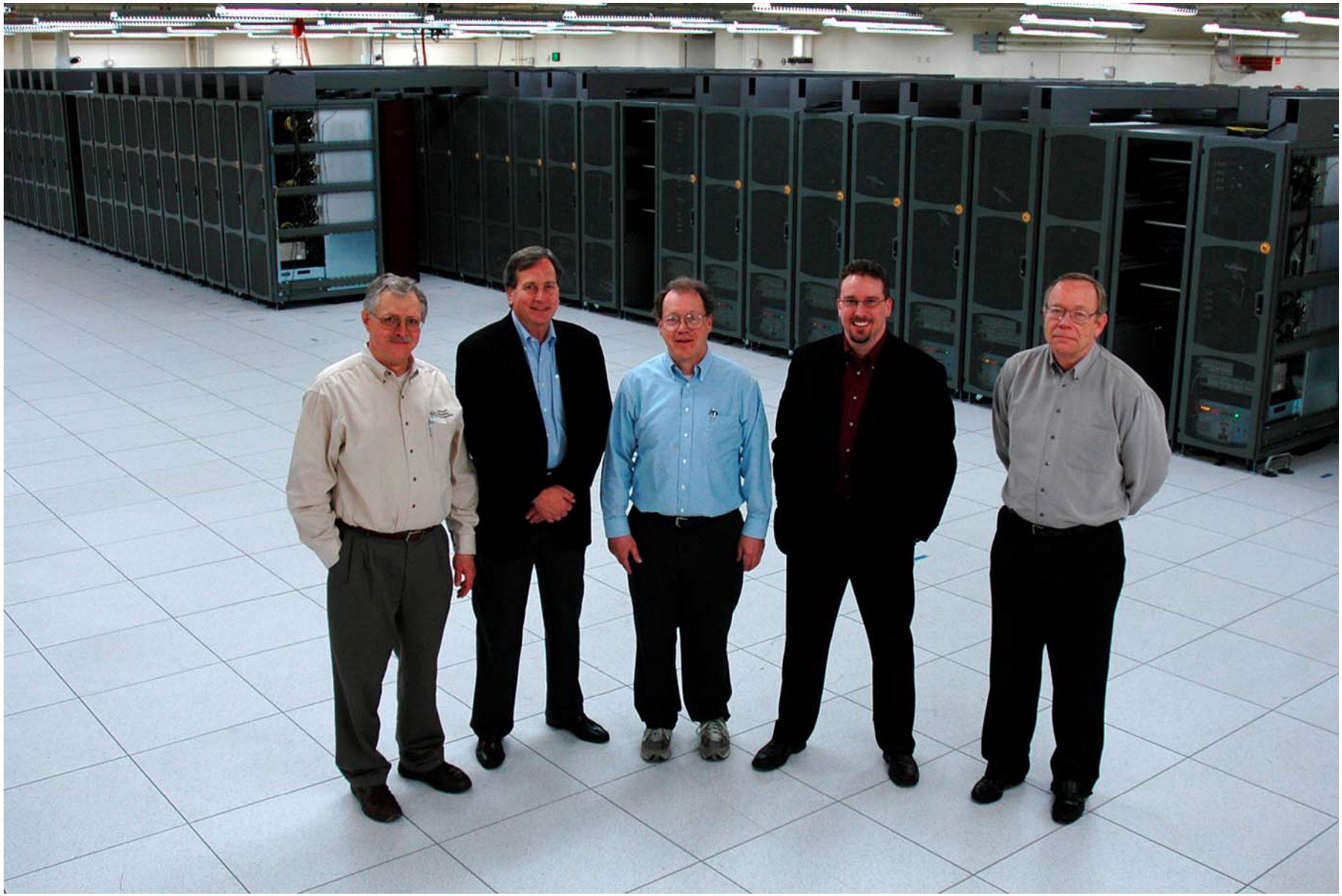

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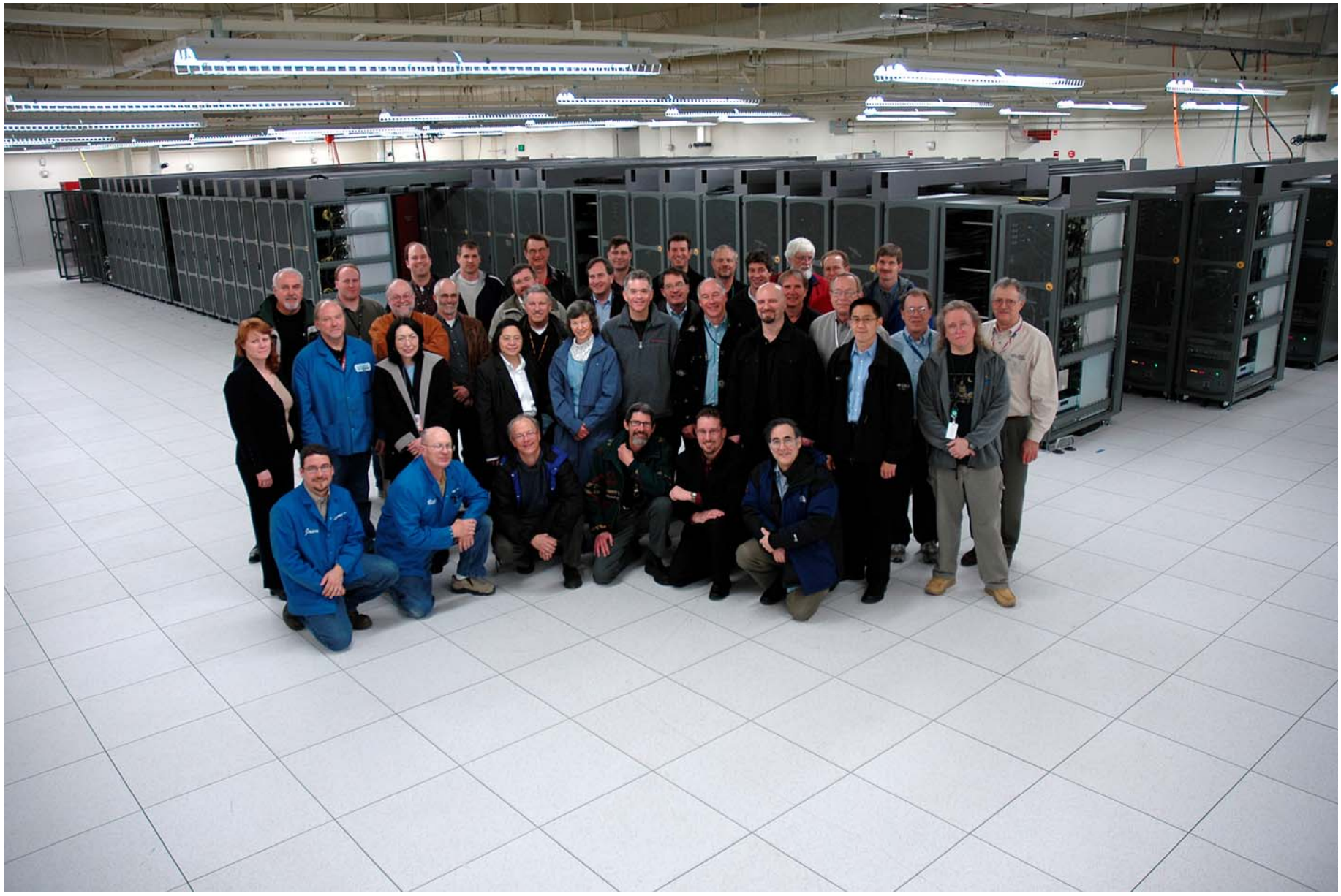

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